Implementation of Median Filter For Noise Removal in Images

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ELECTRONICS AND COMMUNICATION

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INTRODUCTION

Noise can be produced by the image sensor and circuitry of a scanner or digital camera. Image noise can also originate in film grain and in the unavoidable shot noise of an ideal photon detector. Image noise is an undesirable by-product of image capture that obscures the desired information.

Salt and pepper noise is an impulse type of noise in images. We consider salt-and-pepper noise, for which a certain amount of the pixels in the image are either black or white (black or white dots). Normally if there is black dots in the image we called it pepper noise and if there is white dots in the image we called it salt noise. This noise is generally caused by errors in data transmission, failure in memory cell or analog-to-digital converter errors.

If we consider 8-bit image, salt and pepper noise randomly occur where they change certain amount of pixels into two extremes, either 0 or 255 (black & white respectively).

PSNR and SSIM

Peak signal-to-noise ratio (PSNR) is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range

Typical values for the PSNR in lossy image and video compression are between 30 and 50 dB, provided the bit depth is 8 bits, where higher is better.

The Structural Similarity Index (SSIM) is a perceptual metric that quantifies image quality degradation caused by processing such as data compression or by losses in data transmission.

SSIM has been shown to be more accurate than PSNR in measuring image quality.

METHODOLOGY

- The median m of a set of values is such that half of the values are greater than m and half are less than m.

- To implement, sort the pixel values in the neighbourhood, choose the median and assign this value to the pixel of interest. Forces pixels with distinct intensities to be more like their neighbours.
- Generalized expression for median filtering:

$$\boldsymbol{S(x,y)} = \underset{(i,j)\in A_{xy}}{\boldsymbol{median}}\{\boldsymbol{r(i,j)}\}$$

Where ***i,j*** stands for coordinates of the neighbouring pixels
x,y stands for coordinates of the original pixels
Axy refers to the image

METHODOLOGY

Median filtering is excellent at reducing Salt and Pepper noise. The filtering algorithm will scan the entire image, using a small matrix, and recalculate the value by sorting the set of pixels and take the centre pixel values inside the matrix.

[12 23 34]
[22 16 67]
[45 56 78]

Considering the above matrix, the sorted values are:

[12 16 22 23 <u>34</u> 45 56 67 78]

Median of this set is 34.

IMPLEMENTATION

- The filter is a set of pixels that is run through each pixel of the original image, replacing them with the result of the specific operation. The median filter of size n covers n x n pixels with the current pixel at its centre and replaces it with the median of the entire window.
- We use a n x n median filter that replaces each pixel with the median of its respective window and in turn, reduces the noise of the image.
- First, we make an array that is the same size as the original image array.
- We then loop through the pixels of the image and get the left, right, bottom, top, top left, top right, bottom left, and bottom right pixels in addition to the current pixel and store them in temporary variables.
- The median of these variables is then calculated and stored in the resultant array. The previous image after the application of a 3x3 median filter is displayed below, showing significant noise reduction.

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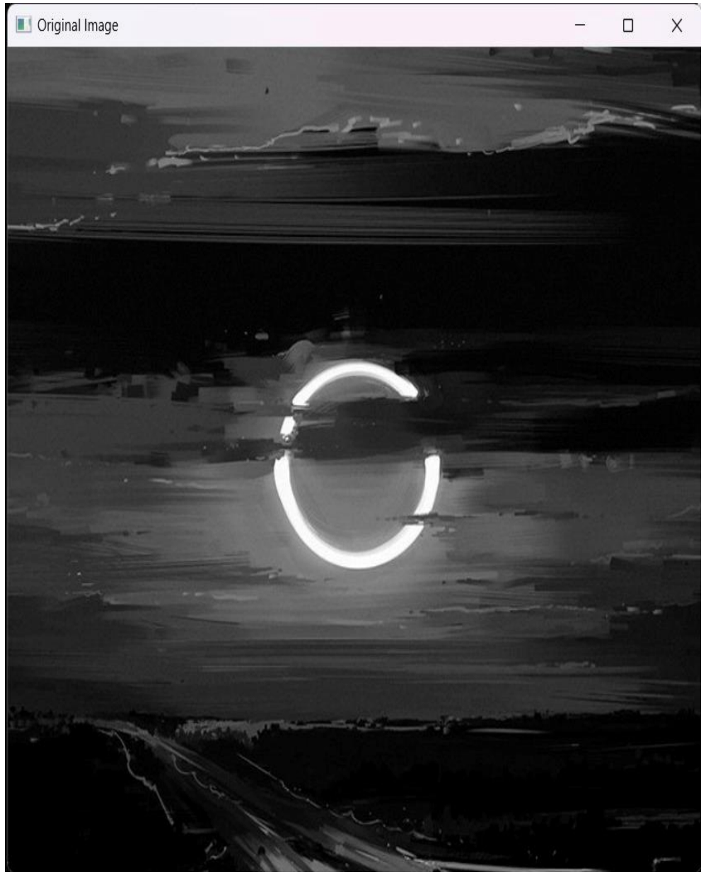
PROGRAM CODE :

```python
import cv2
import numpy as np
from skimage.metrics import peak_signal_noise_ratio, structural_similarity

def add_noise(img, noise_level):
    # Generate random noise of the same size as the image
    noise = np.random.normal(0, noise_level, img.shape)
    # Add noise to the image
    noisy_img = img + noise
    # Ensure pixel values are within the valid range (0 to 255 for uint8 images)
    noisy_img = np.clip(noisy_img, 0, 255).astype(np.uint8)
    return noisy_img

def median_filter(img, window_size):
    height, width = img.shape
    offset = window_size // 2
    filtered_img = np.zeros((height, width), dtype=np.uint8)

    # Pad the image to handle boundary pixels
    padded_img = np.pad(img, offset, mode='reflect')

    for y in range(offset, height + offset):
        for x in range(offset, width + offset):
            window = padded_img[y - offset:y + offset + 1, x - offset:x + offset + 1]
            sorted_window = np.sort(window.flatten())
            median_value = sorted_window[len(sorted_window) // 2]
            filtered_img[y - offset, x - offset] = median_value

    return filtered_img
```

```python
input_image = cv2.imread("Amoledify_1636811191343.jpg", cv2.IMREAD_GRAYSCALE)
window_size = 7  # Adjust the window size as needed (e.g., 3, 5, 7, etc.)
noise_level = 20  # Adjust the noise level as needed

# Add noise to the input image
noisy_image = add_noise(input_image, noise_level)

filtered_image = median_filter(noisy_image, window_size)

# Calculate PSNR
psnr_value = peak_signal_noise_ratio(input_image, filtered_image)

# Calculate SSIM
ssim_value, _ = structural_similarity(input_image, filtered_image, full=True)

cv2.imshow("Original Image", input_image)
cv2.imshow("Noisy Image", noisy_image)
cv2.imshow("Filtered Image", filtered_image)
print(f"PSNR: {psnr_value} dB")
print(f"SSIM: {ssim_value}")
cv2.waitKey(0)
cv2.destroyAllWindows()
```

RESULTS



CONCLUSION

- So in conclusion, Median filtering method can be used as an effective way of noise reduction.
- Median filtering is widely used against salt and pepper noise because of its effectiveness against impulsive noise such as salt and pepper noise.
- It can be further modified to reduce blurring.

FUTURE WORK

- Median filtering can be used to improve the quality of images from traffic cameras. This can help to make it easier to identify vehicles and track their movements.
- Median filtering can be used to improve the quality of images from security cameras. This can help to make it easier to identify people and objects.
- Median filtering can be used to improve the quality of medical images, such as X-rays and MRI scans. This can help to make it easier to identify abnormalities and diagnose diseases.
- Median filtering can be used to improve the quality of images from satellites and drones.

REFERENCES

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- Digital Image Processing 4th Edition by. Rafael C. Gonzalez, Richard E. Woods.